

UNCLASSIFIED

AD 404 613

*Reproduced
by the*

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION, ALEXANDRIA, VIRGINIA



UNCLASSIFIED

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

STANFORD RESEARCH INSTITUTE

MENLO PARK, CALIFORNIA



July 17, 1962

Report No. 20

Bimonthly Progress Report for 1 May to 1 July 1962

THERMOELECTRIC MATERIALS

By: J. W. Johnson

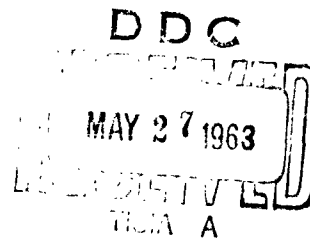
SRI Project No. SU-2681

THIS DOCUMENT MAY BE RELEASED WITH NO
RESTRICTIONS ON DISSEMINATION
RESTRICTIONS ON DISSEMINATION

Prepared for

Chief, Bureau of Ships
Department of the Navy
Washington 25, D. C.

Attention: Code 343



Contract No. NObs-77017
Index Number NS 058-001

Approved:

Charles J. Cook
Charles J. Cook, Director
Chemical Physics Division

Copy No. 17

CATALOGED BY ASTIA 404613
AS AD

I INTRODUCTION

This Progress Report describes the work performed under Contract NObs-77017 (Index Number NS-058-001) on thermoelectric materials for the period 1 May to 1 July 1962 and outlines the proposed effort for the next period.

II WORK PERFORMED

Cuprous Sulfide-Cuprous Telluride -- Measurements have been made to determine the Seebeck coefficient and resistivity for the sample of 75% cuprous telluride and 25% cuprous sulfide used by Westinghouse to measure the liquid thermal conductivity. The procedure used was to melt the entire sample received in order to homogenize it and quick-cool the sample to prevent segregation on solidification. The entire sample was then ground in a mortar to a powder, mixed well, and a portion removed and placed in the cell for measurement of the Seebeck coefficient and resistivity. Table I presents the experimental values obtained. For purposes of comparison the corresponding values obtained for this composition prior to the thermal conductivity measurements at Westinghouse are included. Because of the wide variation of the initial and final measurements on this sample, a second preparation of this composition was made from the elements and the Seebeck coefficient and resistivity were determined. From an examination of Table I it is evident that the differences between the initial and final values of these parameters for the thermal conductivity specimen are much greater than the variation between the two preparations, particularly in the resistivity.

As was stated in Report No. 19 the sample on which the thermal conductivity measurements had been performed contained a large amount of copper whiskers. Excess copper in cuprous sulfide tends to lower the Seebeck coefficient of the liquid and to lower the resistivity to a

Table I

THERMAL CONDUCTIVITY SAMPLE									
INITIAL					FINAL				
T (°C)	S(μV/°C)	T (°C)	ρ(Ω cm x 10 ³)		T (°C)	S(μV/°C)	T (°C)	ρ(Ω cm x 10 ³)	
1219	+165	1211	1.53		1208	+146	1201	3.13	
1183	170	1176	1.55		1168	155	1164	3.19	
1156	169	1150	1.56		1121	164	1114	3.78	
1131	172	1124	1.57		1116	165	1110	3.51	
1110	169	1099	1.57		1084	171	1080	4.08	
1080	172	1075	1.58		1077	178	1069	4.16	
1054	175	1048	1.58		1067	180	1061	3.95	
1032	175	1023	1.58		1042	190	1034	4.22	
1007	175	1000	1.58		1031	193	1011	3.95	
976	172	965	1.58		1013	196	1010	4.58	
960	173	950	1.57		995	195	989	5.37	
941	175	928	1.48		958	258	950	5.36	
917	166	905	1.25		928	263	920	5.10	
889	151	875	1.03		905	265	898	4.98	
863	137	850	0.87		877	268	369	4.79	
817	123	825	0.77		842	260	835	4.57	
		814	0.75		758	243	751	3.92	
		805	0.72						
RECENT PREPARATION									
T (°C)	S(μV/°C)	T (°C)	ρ(Ω cm x 10 ³)		T (°C)	S(μV/°C)	T (°C)	ρ(Ω cm x 10 ³)	
1208	+148	1201	1.57						
1164	159	1159	1.54						
1122	157	1115	1.58						
1093	158	1088	1.54						
1071	163	1069	1.54						
1047	158	1041	1.58						
1042	165	1036	1.54						
1019	166	1012	1.54						
1000	158	991	1.56						
974	165	970	1.53						
952	162	946	1.38						
937	159	930	1.20						
914	150	906	0.96						
895	148	889	0.88						

smaller extent. However, the effect in this composition has been to raise the Seebeck coefficient slightly at the lower temperatures and to raise the resistivity by a factor of between 2 and 3 over the liquid range. Reasoning by analogy with the copper-sulfur system one would conclude that other changes, in addition to loss of tellurium, must have occurred. A possible explanation lies in oxide formation during the prolonged heating for the thermal conductivity measurements. Figure 1 shows the extent of modification in the Seebeck coefficient and resistivity which occurred. In addition the quantity S^2/ρ is plotted for the three sets of measurements.

The smoothed values for the liquid thermal conductivities of 75% Cu_2Te and 25% Cu_2S have been received from Dr. E. W. Johnson of Westinghouse. Using these values a value for ZT may be calculated for this composition. These are considerably lower than estimated from preliminary data, primarily because of the increase in resistivity observed in the final measurements. However, neither the loss in tellurium nor the formation of oxide should modify extensively the "lattice" thermal conductivity of the liquid, and therefore it is a good approximation to use the measured values of the conductivity with the values of the Seebeck coefficient and resistivity as determined prior to the conductivity determination. Table II presents the quantity ZT for the three sets of measurements and Figure 2 shows the same information graphically.

Table II

<u>T (°C)</u>	<u>ZT for 25% Cu_2S 75% Cu_2Te</u>		
	<u>Initial</u>	<u>Final</u>	<u>Recent</u>
1200	1.27	0.49	1.06
1150	1.38	.54	1.18
1100	1.52	.63	1.32
1050	1.73	.73	1.48
1000	1.98	.86	1.72

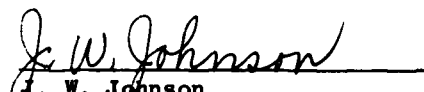
Bismuth-Sulfur System -- Work on this system was halted in order to examine the cuprous telluride-cuprous sulfide samples and complete this phase as rapidly as possible.

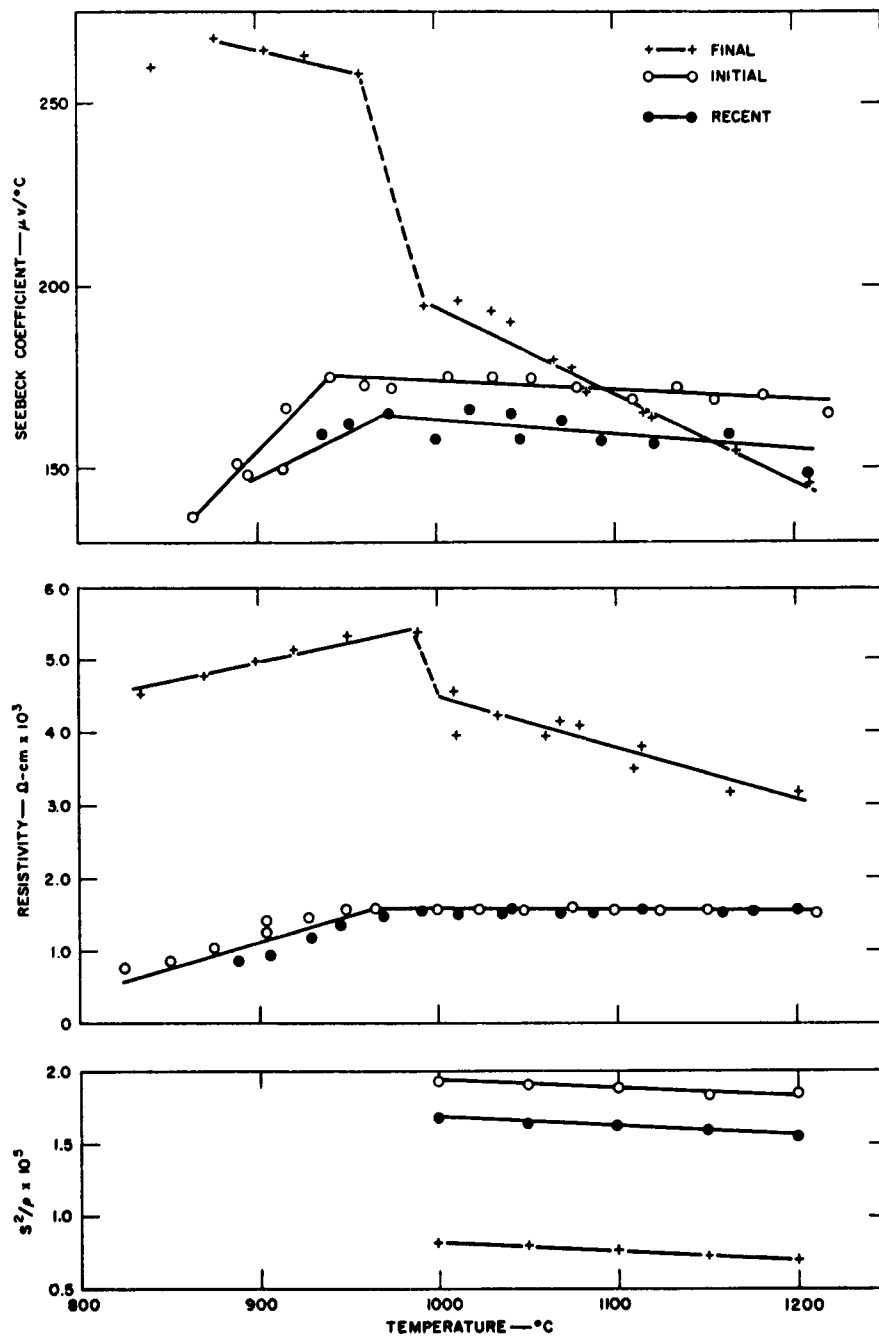
III WORK PLANNED 1 JULY TO 1 SEPTEMBER 1962

Work will be continued on the bismuth-sulfur system, and its mixtures with cuprous sulfide will be examined.

IV CONTRIBUTORS

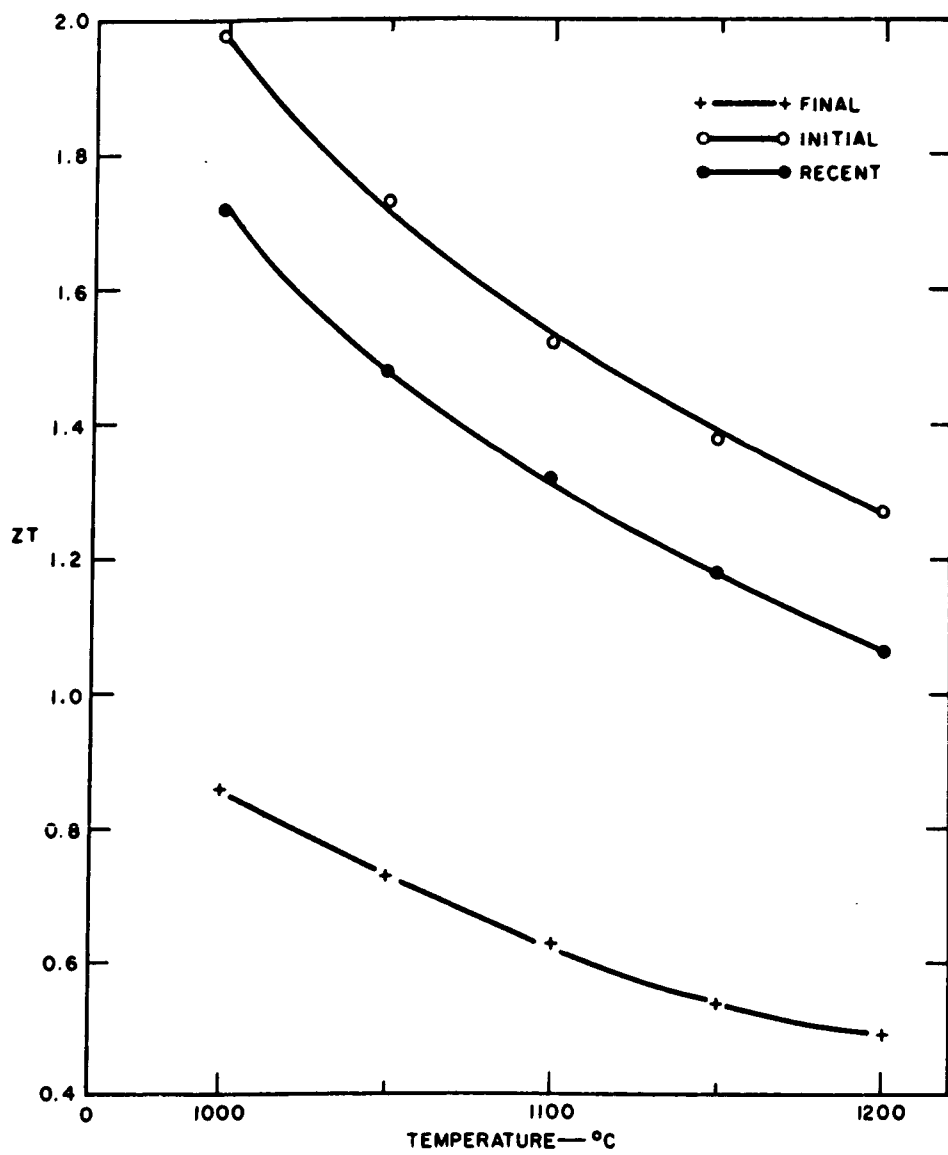
Mr. G. Withers and Dr. J. W. Johnson prepared various compositions and made electrical measurements.


J. W. Johnson
Senior Physical Chemist



8-2681-24

FIG. 1



A-2681-25

FIG. 2